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**MONOGRAPH**

# Diversity and systematics of amphipods in Swiss rivers: River network structure shapes community structure

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**ABSTRACT** We show that both native and non-native amphipod community assembly in river networks are influenced by the connectivity of habitats.

**KEY WORDS** Amphipoda; Biodiversity; Community Assembly; Habitat Connectivity; Invasion Biology.

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Amphipods represent keystone species in many aquatic ecosystems and they contribute substantially to the biodiversity and functioning of macroinvertebrate communities in these habitats (Holsinger, 1976). Hence understanding their ecology and systematics is crucial for conservation measures. Especially in Europe there is a relatively high proportion of non-native amphipod species reaching new habitats (Bij de Vaate et al., 2002), and new conservation challenges arise. Furthermore, for the European Alps in general and Switzerland in particular, only limited information on amphipods has been available until recently (Altermatt et al., 2014).

Biological communities and hence patterns of biodiversity are shaped by habitat connectivity and dispersal of organisms. River networks offer unique possibilities to study these processes in a spatially explicit manner. Predictions from theoretical work imply that network structure has a major influence on measures of diversity (Carrara et al., 2012). Furthermore, experiments and data from fish or bacterial communities support these expectations (Muneepeerakul et al., 2008; Besemer et al., 2013). On a global scale, rivers not only show these characteristic diversity patterns, but are also strongly affected by non-native species. They represent a major challenge for conservation biology and can have detrimental effects on native communities (Chandra & Gerhardt, 2008). Nevertheless it was rarely studied how the river network structure shapes the occurrence of non-native species. Here we present results on the spatial distribution of amphipod communities throughout Switzerland. We specifically studied the spatial imprint of the river network structure on communities of native and non-native amphipod species in Switzerland.

We collated an extensive database on amphipod occurrences in Switzerland, covering over 1,700 sites and 41 species and its underlying river network. Data origin from published literature, the biodiversity monitoring program of Switzerland (BDM coordination office, 2009), grey literature such as reports from environmental agencies and our own extensive sampling. Community data were analyzed as presence-absence matrix and summarized in 1000 $km^2$ subcatchments. Our analysis in the river Rhine drainage revealed distinct

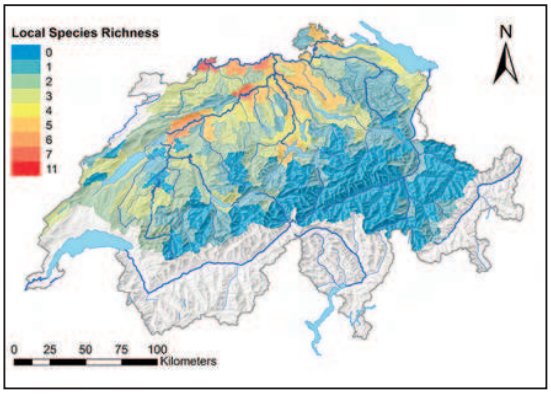


Figure 1. Amphipod richness in the river Rhine drainage in Switzerland. Data source: swisstopo (Art. 30 GeoIV): 5704 000 000 / swissTLM3D 2014, (reproduced with permission of swisstopo / JA100119)

patterns of local species richness along the river network and different distributions of native and non-native amphipod species. Species richness increases along the network from headwaters to the outlet site (Fig. 1).

This implies sufficient levels of dispersal between amphipod communities along the network. But non-native species are still mostly restricted to larger and better connected streams, whereas small and more isolated headwaters represent refugium habitats for native species. Species turnover (β-diversity) of native species shows the classical distance decay between sites in the network. Their communities are less similar with increasing distance. This suggests that native species might be dispersal limited. On the other hand, similarity of non-native communities between sites in the network is not decreasing by distance. This implies a potential influence of habitat filtering or minor dispersal limitation on non-native amphipod diversity. The modularity of the network has a significant imprint on amphipod communities. Overall, the expected diversity patterns are only observed when taking into account both native and non-native species. Furthermore, our results improve the knowledge of Swiss amphipods and our understanding of the influence of spatial connectivity on biodiversity and invasion processes in natural systems.

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